A Reference Framework for Enterprise Computing Curriculum

Munir Majdalawieh(✉) and Adam Marks

College of Technological Innovation, Zayed University, Dubai, UAE
{munir.majdalawieh,adam.marks}@zu.ac.ae

Abstract. An increasing number of universities are offering one form or another of Enterprise Computing (EC) program, while simultaneously a number of enterprises in the private and public sectors have articulated needs for graduates with knowledge in enterprise applications, analytical skills and competencies. The programs often are structured by the knowledge of their faculty and in collaboration with Enterprise Application Solutions Vendors (EASV) providing solutions in this space. Based on their perception of the educational needs of their primary stakeholders (students, parents, employers, society), both within industry and government. This perception of audience needs is often based on interviews, exchange forums, surveys, and informal assessments. As of now, there is no EC reference curriculum identified by academia or industry. Industry and academia often differ in the definition of the scope of EC curriculum. Consequently, the need for a reference framework for enterprise computing curriculum has often been articulated in a variety of meetings within the enterprise community. The aim of this paper is to propose an EC reference curriculum at the undergraduate level based on the expertise of the authors, a study of the EC program at several local, regional, and international universities, the industry needs of EC competencies and the best practices available in academia and industry.

Keywords: Reference curriculum · Reference framework · Enterprise computing · Enterprise Application Solutions Vendors (EASV) · Enterprise systems · Enterprise solutions

1 Introduction

Enterprise organizations must face the realities of the 21st century economy as knowledge becomes the primary economic resource and markets becomes more complex and competitive. For companies to succeed in this economy, they must participate with their partners in a collaborative network to share their complementary strengths and capabilities, have on-demand access to information and resources and improve agility in dealing with operational challenges in order to achieve some common goals and to compete more effectively on the national, regional and international levels. In such economy, companies need enterprise computing experts to help to improve resource

Á. Rocha et al. (eds.), *Recent Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 570, DOI 10.1007/978-3-319-56538-5_87

utilization, improve business processes efficiency and effectiveness, maximize flexibility, rapid elasticity, improve accessibility, increase client empowerment, increase collaboration and communication, and to reduce cost and economies of scale.

Universities must respond to these challenges by introducing new programs to develop and produce students and graduates ready to function in the 21st century knowledge economy. These students will gain an understanding of end-to-end systems solutions found in a modern organizations and can be the resource that these companies need.

At the same time, Enterprise Application Solutions Vendors (EASV) like SAP, Oracle, IBM, HP, Microsoft, and many others have recognized the lack of enterprise computing expertise over the coming years due to the exponential growth of the development, deployment, integration, maintenance, and management of enterprise applications on premise or in the cloud. They need graduates with a mixed of IT and business knowledge in the area of enterprise business systems (EBS). It will be very costly for these companies and their end-users to hire fresh graduates with degrees in business or IT or a combination with no hands on experience with their solution packages. By recognizing this gap, most of these EASVs established an academic initiative in the form of partnership programs with universities in which universities access the EASV's latest technologies and solutions, to give students hands-on experience with the technology, and to give the faculty the training to teach students the required knowledge.

To this extent, many universities have established strategic partnership agreements with one or more of the EASV to design and develop an enterprise computing curriculum to meet the enterprise competencies sought by industry and the national needs. It is important to note that partnerships with only one vendor can be somewhat problematic, especially for universities funded by taxpayers' money. However, this topic is beyond the scope of this paper.

In order to understand the complexities of managing global enterprises, the term enterprise computing needs to be closely examined. According to Shan and Earle [14] Enterprise Computing "*involves the development, deployment and maintenance of the information systems required for survival and success in today's business climate*".

Laudon and Laudon [16] state that enterprise computing is a method of planning and designing of systems that "*integrates the key business processes within a firm and even integrates business processes across an entire industry*". A business process is a set of interrelated activities/routines across the enterprise functional areas (marketing & sales, accounting & finance, Human Capital, manufacturing & production, etc.) with flow of information, material, and finance in an effective and efficient way to meet the goals and objectives of the enterprise.

This paper focuses on proposing an enterprise computing reference curriculum at the undergraduate level based on the expertise of the authors, a study of enterprise computing programs at several local, regional, and international universities, the industry need of EC competencies, and best practices.

The remainder of this paper is organized as follows. First, a review of enterprise computing academic programs is presented. Then, the research gap, statement of the problem and the contribution of the study will be discussed. Following the methodology of the study will be discussed. Next, the Enterprise Computing Programs and Curricula

will be conferred, followed by the proposed EC reference curriculum will be presented. Finally, remarks, recommendations and future directions are presented.

2 Review of Enterprise Computing Academic Programs the Study

2.1 The Name of the Academic Program

In many cases, the terms "enterprise computing", "enterprise systems", "enterprise applications", and "business solutions" are used interchangeably by universities to describe the same major. Because of the different naming conventions, this research focuses more on the course requirements. The requirements of the academic program are composed of core, major, required and elective courses based on the home of the major that lead to a university degree. The truth is, what you name your program does matter, but for consistency and for the sake of this study, we will use the term "Enterprise Computing" throughout this paper to refer to the same set of course requirements.

2.2 The Home of the Academic Program

The Enterprise Computing major can be found in business colleges or information technology colleges. Depending on the home of the Enterprise Computing academic major, the most common three options for undergraduate degrees are:

- Bachelor of Science, Major in Enterprise Computing [BS(EC)], College of Information Technology (& Systems):
  - Depth in technical skills complemented by breadth in statistics and business.
- Bachelor of Science, Major in Enterprise Computing [BS(EC)], College of Business:
  - Business emphasis first (accounting, finance, sales & marketing, etc.) supported with enterprise technical skills and provide problem solving ability in business decision making.
- Bachelor of Science, Major in Enterprise Computing [BS(EC)], Joint Between College of Business and College of Information Technology:
  - Combined technical skills with business skills (offered through the College of Information Technology in cooperation with the College of Business).

The focus of this paper is to propose a curriculum reference framework for the Bachelor of Science, Major (Specialization) in Enterprise Computing in the college of Information Technology (& Systems). We will leave the other two majors for future research work.

3 Research Gap, Statement of the Problem and Contribution of the Study

Several researchers and practitioners have proposed various frameworks for academic program structure in information systems and information technology. Some of the names include: (The Association for Computing Machinery (ACM) [2], and the

Association for Information Systems (AIS), [5, 6, 15]). In researching the literature on developing a framework for enterprise computing curriculum and until currently we found no substantial evidence of research in this area. The development of such a program will benefit higher education institutions (HEI), the industry, and the community. The development of an enterprise computing program is underway in several institutes, but it lacks a reference framework and structure. ABET [1] defines an educational program as "*an integrated, organized experience that culminates in the awarding of a degree. The program will have program educational objectives, student outcomes, a curriculum, and facilities.*" The development of an enterprise computing academic program to achieve its objectives and student's outcomes involves more than the adoption of definitions provided by any accreditation body. The curriculum reference should answer important questions such as: *What is the main objective of the EC curriculum (acquired qualifications)? What is the content (courses and relevant material) that the students will be taught? How should the content be delivered to the students (teaching methods)? And how will the curriculum will evolve (evaluation methods, plans and strategies)?*

Enterprise computing is not offered by too many HEIs. For the sake of this study, information from websites, catalogues, published paper, and other publicly available documents of 10 different universities were collected. The data collection focused on the EC core courses, EC specialization courses and elective courses including: course name, course number, course description, course outline, and course pre-requisite or co-requisite. Over 100 courses were analyzed and an initial set of Enterprise Computing topical areas were identified. Through several iterations [7], each course was reviewed and defined by eliminating overlaps, gaps, redundancies and consolidating multiple course titles for similar topics.

As such, the research question for this study is to "*design and develop an Enterprise Computing Reference Curriculum at the undergraduate level*". Such framework is designed and developed based on the expertise of the authors, a study of the EC program at several local, regional, and international universities, the industry needs of EC competencies and best practices.

4 Methodology

This study used the same research methodology of Jain and Verma [8] outlined in their study to develop the reference curriculum for the EC program. The methodology consist of several steps as follows:

- Research on the current EC centric curriculum
  - Identify EC Centric programs
  - Gather program and curriculum information of all identified EC centric undergraduate programs
  - Identify topical areas by performing pattern analysis on the consolidated and synthesized curriculum information
- Research on the industry need of EC competencies
  - Research on industry needs for EC competencies

  - Consolidate and synthesize a list of industry required EC competencies
- Propose a reference EC undergraduate curriculum
  - Map the identified topical areas with the required EC competencies
  - Perform gap analysis on the mapping
  - Propose an undergraduate curriculum based on the gap and pattern analysis

A number of industry and government surveys and studies [3, 4, 10] formed the basis for understanding the required technical competencies, knowledge and skills. Detailed references to a selection of these studies are provided in the paper.

5 Enterprise Computing Programs and Curricula

5.1 Research on the Current EC Centric Curriculum

Enterprise computing is a platform that integrates key business processes within all functional areas and the supply chain of a company and involves the development, deployment, maintenance and operation of the information systems which involve the use of the right IT infrastructure to help an organization succeed in today's complex business environment. To fulfil the need of this platform, the reference curriculum framework should include components of information systems and information technology.

The Association for Computing Machinery (ACM) and the Association for Information Systems (AIS) [2] published curriculum guidelines for undergraduate degree programs in Information Systems (IS) [15], and ACM and IEEE Computer Society published curriculum guidelines for undergraduate degree programs in Information Technology (IT) [6]. Hansen et al. [5] compiled a master list of 909 institutions operating in the United States with one form of computing programs. Of those programs, 220 were identified as being close enough to IT programs. In addition, Hansen et al. [5] provides a list of different names the IT programs were known by, and the respective number of each. 62 of the 220 university refer to the program as BS, Information Technology. Topi et al. [15] identified three IS knowledge and skills categories to be considered when designing and developing an IS program: IS specific knowledge and skills (identifying and designing opportunities for IT-enabled organizational improvement, analyzing trade-offs, designing and implementing information systems solutions, and managing ongoing information technology operations); Foundational knowledge and skills (leadership and collaboration, communication, negotiation, analytical and critical thinking, including creativity and ethical analysis, and mathematical foundations); and Domain fundamentals (general models of a domain, key specializations within a domain, and evaluation of performance within a domain). Lunt et al. [6] depict the academic discipline of Information Technology and identify the following pillars of IT: programming, networking, human-computer interaction, databases, and web systems. These pillars are built on a foundation of knowledge of the fundamentals of IT and overarching the entire foundation and pillars are information assurance and security, and professionalism. Information Systems (IS) professionals are interested in the application of information technology to business activities. They are concerned with the design and

implementation of information systems to support the information processing needs of an organization. So, we need to design a curriculum to focus on the problem space of computing that students typically do after graduation [2]. ACM [2] illustrates by graphical characterizations the commonalities and differences among the computing disciplines (IT, IS, CS) by suggesting how each discipline occupies the problem space of computing. The space of computing illustrated by identifying a horizontal range (x-axis) from Theory, Principles, Innovation, to Application, Development, Configuration. The vertical range (y-axis) runs from Computer Hardware and Architecture, to Organizational Issues and Information Systems. We use the same theme to develop the below figure to illustrate the characteristics of EC discipline (Fig. 1).

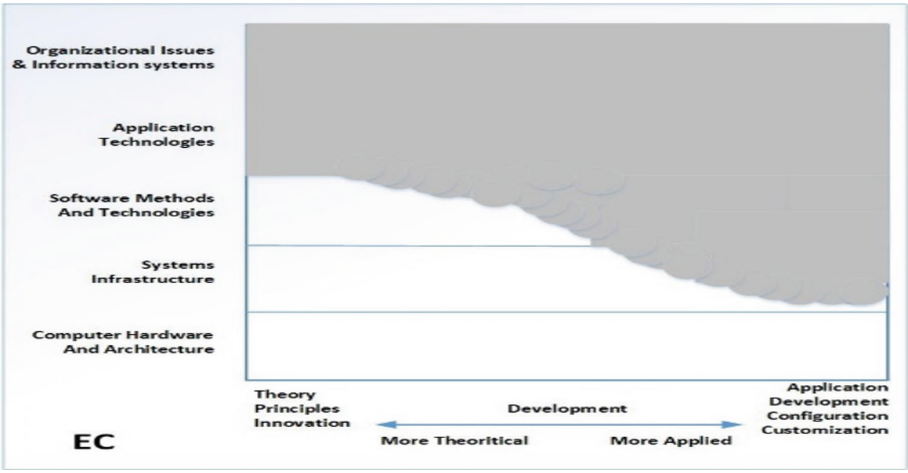


Fig. 1. Characteristics of the enterprise computing discipline

By applying the same problem space of computing to enterprise computing, vertically the focus is on people, information, organizational workplace, application technologies, software methods and technologies and systems infrastructure. Horizontally, the focus is on application implementation, customization, configuration and integration to solve organizational problems. As a result of the survey and the analysis of the above sources, the typical course requirements for an IT degree program are of four types, and together comprise the 120 semester credits: the general education, college core requirements, field of concentration (major) requirements, and free electives. At minimum, 66 of the required 120 credits must be from courses within the college of IT. The general education courses are intended to help students place the specialized study within a broader context. College core courses must be chosen as per the posted guidelines set by the college. Field of concentration courses must be chosen from offerings by the college, and free electives may be chosen from throughout the university.

By conducting further curriculum gap analysis and cross-referencing courses offered by the above specializations (majors), we developed a comprehensive list of course titles and descriptions that can be used for a proposed enterprise computing curriculum framework. Once the baseline course titles and descriptions [7] were finalized, each

course was placed into one of four levels: Level 0: Fundamental Courses, Level 1: Fundamental (introductory) courses, Level 2: Core Courses and Level 3: Specialization Courses. After cross referenced the courses among the universities listed above, the final grouping of the topical areas into levels [8] is identified as follows:

- Level 0: Foundation courses
  - Pre-enterprise computing courses. Students must be competent in these areas to enter the enterprise computing program
- Level 1: Fundamental (Introductory) courses
  - Fundamental computing and IT concepts, underlying technologies, business, accounting and management concepts
  - These are the initial courses taken in the enterprise computing program
- Level 2: Core Courses (college specific)
  - Various aspects of computing skills and knowledge of information systems or information technology

Table 1. Topical areas grouping into curriculum levels

Level	Tropical area	
0: Foundation courses (6 credits)	1.	Mathematics for IS
	2.	Probability and statistics for IS
1: Fundamental (introductory) courses (9 credits)	3.	Fundamental of enterprise information systems
	4.	Integrative programming & technologies
	5.	Introduction to security basics
2: Core courses (21 redits)	6.	Management information systems
	7.	Database management systems
	8.	Technical and professional communication
	9.	Human computer interaction
	10.	Systems analysis and design
	11.	IT project management
	12.	IT innovation & entrepreneurship
3: Specialization (major) courses (27 credits)	13.	Enterprise resource planning
	14.	IT in logistics and supply chain
	15.	Enterprise systems developments
	16.	Business process management
	17.	IT management, strategy & governance
	18.	System integration and architecture
	19.	IT audit, assurance and control
	20.	Applied database systems
	21.	Senior project/capstone

  - Required core courses towards the completion of an undergraduate degree in information systems or information technology. These are recommended as core courses in any information systems or information technology program
- Level 3: Specialization Courses
  - Either advanced courses which focus on enterprise computing niches or special areas related to enterprise information systems
  - Advanced courses in areas such as Information System Management, IT Audit & Control, Decision Support, Knowledge & Project Management, Business Process Management, Logistics, SCM and Workflow
  - Students focus on specialization courses once the initial and core courses are complete

In the current EC programs, several courses are included as part of the core courses. We believe that some of these courses should be included as a specialization, and it is categorized as a specialization course in the proposed framework. The grouping of the twenty-one topical areas into four levels are shown in Table 1.

5.2 Research on the Industry Need of EC Competencies

The world of information technology is evolving all the time requiring new talent and forcing universities to be more proactive to review, assess, and update their academic curricula on a regular basis for their graduates to be competitive in today's job market and to keep on pace with industry talent needs and demands. The current competitive environment is defined by four main factors (continuous technological developments, shorter product life cycles, increasingly demanding consumers and global competition) [4] which are evolved around the human capital talent.

Mr. Jonas Prising, ManpowerGroup [10] CEO, said that the recent financial crises have "transformed the employment landscape." He added that "we have seen the emergence of the Human Age, where talent is the new differentiator." And "through all of this uncertainty, the one constant is that talent shortages continue unabated." And "talent shortages are something companies struggle with all over the world." He was referring to the results of the survey that his company has conducted in 42 countries and territories in which more than 41,700 hiring managers participated in the survey." [10]. The first step to address talent shortages is to have a talent strategy and it should be aligned with business strategy. Moreover, with the intensive competitive environment that we are witnessing in the "knowledge intensive economies" has reinforced a growing consensus on the key role that human capital talent plays in sustaining economic growth and enterprises' competitiveness (European Commission 2003). The knowledge has become one of the most important inputs underpinning economic development and competitive advantage. The skills currently required are a mixed of technical nature ("hard" skills), organizational and social character ("soft" skills) [4].

European Commission [4] identified several "soft" skills competencies to be required by enterprises in the future including: information processing and management, analytical skills, creative thinking and problem solving skills, decision making skills, communication skills, language skills, teamwork, management & leadership, strategic thinking, and self-management & self-development.

Talent shortages are most likely to have negative impact on companies. As reported in ManpowerGroup [10] survey, 42% of employers feel that more limited ability to serve clients and reduced competitiveness/productivity are most likely to be regarded as the key business consequences if they can't hire all the talent they need. Followed by 30% expect an increase in employee turnover and 26% anticipate lower employee engagement and morale. Around one in four (25%) expects reduced innovation and creativity in their organization and the same proportion say talent shortages can lead to higher compensation costs. In the changing landscape of higher education, strong partnership between businesses and universities must be a priority to respond to the talent shortages and to help businesses drive their future plans [3]. More than 542 employers collectively employing some 1.6 million peoples in the UK responded to CBI/Pearson education and skills survey. In the same survey, two thirds (63%) of employers indicated that they have developed links with universities in activities ranging from providing sandwich-year and other placements to a role in shaping degree programmes. Furthermore, almost half of employers (47%) offer internship opportunities of some type for graduates. Employers want to see universities upping their game by enhancing students' employability skills (65%) and increasing the business relevance of undergraduate courses (61%).

Employers believe universities should be providing more programmes to develop employees (a priority for 31% of employers) and increasing number and quality of STEM graduates. Most employers want workers who are able to solve problems using science, technology, engineering, and math (STEM) skills and knowledge.

STEM integrates these fields into one learning experience and develop "soft" & "hard" skills to prepare students for integrated careers. These "soft" skills include: communication and cooperation skills, creative skills to solve problems, innovative skills to develop new ideas, leadership skills, and organization skills.

Thus, a STEM-based enterprise program designed to improve academic achievement. A well-developed STEM-based curriculum focused on creativity, innovation, and reasoning, blended with strong commitment to STEM disciplinary knowledge. At the core of quality STEM learning are teachings of inquiry, critical thinking, problem solving, and creativity [11]. STEM is a multi-faceted and inter-disciplinary approach, not just in the areas of science, technology, engineering or mathematics, but also integrating subject matter that may be relevant to problems such as environmental, social, regulatory, political and economic aspects [13]. Enterprise systems deals every day with very complex and 'messy' small and large problems, and for this reasons enterprise systems graduate needs to be equipped with skills and knowledge based on a successful STEM-based program (Roma 2012). STEM-based disciplinary skills and knowledge is essential component of any modern enterprise systems curriculum.

Nightingale [12] proposed a framework for enterprise principles and transformation methodologies that consist of a set of interdependent methodologies, tools and enterprise principles which support holistic enterprise transformation with five elements:

Enterprise Thinking, Enterprise Transformation Roadmap, Lean Enterprise Self-Assessment Tool (LESAT), Enterprise Strategic Analysis for Transformation (ESAT), and Enterprise Architecting Framework. These elements will be part of the EC Competencies.

Every company is organized their employees into key functional areas such as sales, marketing, operations, finance and accounting, customer service, supply chain management and logistics, human resources and technology which work together to achieve the goals of the company. Functional areas are teams of employees who have similar skills and expertise. Companies organized by functional areas for many reasons including: more efficient to group employees with similar skills and expertise; team up on projects requiring same and complement expertise; backup expertise in case one employee is unable to complete their task; makes training and knowledge sharing easier. Several universities are offering a course in business functional areas to provide students with an overview of the functional areas of a business and to explore how these areas complement each other to contribute to achievement of the organization's goals. Companies are looking for solution analyst talent to design and develop solutions for the business functional areas. This includes reviewing business requirements, designing system solutions, working with IT and business teams to develop solutions.

Most companies provide universities with Enterprise Application solutions across the value chain in the areas of: Enterprise Resource Planning (ERP), Supply Chain

Table 2. EC competencies

STEM	Enterprise thinking [12]	Holistic lifecycle view	Enterprise system design	Systems management
STEM skills & knowledge	Enterprise concepts and principles	Plan, determine and manage stakeholder requirements	IT Architecture Framework	Business process management
Creativity, innovation, and reasoning	Internal and external enterprise interdependencies capability issues	Enterprise system requirements	Functional analysis	Enterprise integration
Inquiry, critical thinking, and problem solving	Strategy, business and technology environment		Data and interface management design	Planning, monitoring and controlling
			Modelling and simulation	Logistics and operation
			Select preferred solution	Enterprise systems management: governance, risk, and compliance (GRC)
			Testing, integration & verification	
			Transition to operation	

Management (SCM), Logistics Management (LM), Supplier Relationship Management (SRM) and Customer Relationship Management (CRM). For example, SAP has established a "University Alliance Program" (UAP) in which members universities gain access to range of opportunities including: access to full SAP solutions from ERP, SCM, Business Analytics to Mobility, HANA to BPM; access SAP curriculum and integrate parts of it to create entirely new courses; take part in SAP students' competitions and contests; get involved with Co-Innovation projects with customers and partners in the SAP universe; and get directly involved in research and the development of new SAP solutions. As of October, 1, 2014 more than 1,800 universities already signed up with SAP. Specializing in one functional/technical areas is essential to meet the future career needs as it is identified by EASV.

Enterprise Computing graduates can take up position ranging from inventing new technologies or new principles to helping organizations integrate off-the-shelf products to solve companies' business problems to help companies on assessing how technology can work for them and their impact. As such a range of technical positions are available for EC graduates such as programmers/analysts, system analysts, solution analyst, solutions architect, functional technical analyst, technical consultants, business process effectiveness specialists, software/system developers, software engineers, software specialist, and system/application administrators, and less technical positions including technical sales support, sales engineers, project/product managers, web/database/network administrators and web services designers. The list of EC Competencies obtained from the above sources and considered for this study is shown in Table 2.

6 Gap Analysis: Map Curriculum Level Grouping to Industry Needs

Next, we cross-referenced the topical areas and their curriculum level groupings to industry needs through a Six-Sigma Quality Function Deployment (QFD) exercise to identify gaps in the process or gaps in the ability to meet industry needs, as shown in Appendix A. This process was repeated until industry needs were sufficiently addressed, and the topical areas were refined into a suggested EC curriculum. The correlation entries in Appendix A are "Strong Positive," "Medium Positive," "Weak Positive," and "No Correlation".

In reviewing existing EC programs and mapping their offerings to industry needs, we identified missing topics and topics that could be strengthened. The gap analysis showed that the current EC centric programs do not address the following industry-required EC competencies:

- Inquiry, Critical Thinking, and Problem Solving
- Modelling and Simulation
- Functional Analysis
- Creativity, Innovation, and Reasoning

To fill these gaps, the research revealed that the following specialization courses had a weak relationship or absence of any relationship with the other topical areas:

- Research Design & Data Analytics
- Modeling and simulation
- Functional Technical Areas
- Emerging Technology for the Enterprise

The intent of this correlation is to embed enough correlating themes in these courses to allow the emergence of an appreciation for the crosscutting implications of the topics when applying a enterprise systems approach. We believe that a mature and evolving curriculum will allow sufficient links across courses to exemplify this enterprise systems perspective.

7 Proposed Framework

A framework for a reference curriculum in enterprise computing at the undergraduate level is proposed to be used as a guideline for universities. The proposed framework takes into consideration the commonalities and patterns in enterprise information systems content based on the discussion in the previous sections. A combination of Information Technology courses (ITC), where students apply more-than-basic IT-related knowledge/skills to be able to function in knowledge intensive workplaces; Management Information Systems (MIS) courses, where students apply their IT skills and knowledge to work in teams to design, plan, and develop a solution to contemporary computer information system problem; IT Operations/Business courses (ITB), where students concentrate on business operations related to computing business processes; Application Development courses (ADC), where students train to simplify the tasks of the end user or resolve recurring problems through process automation; and Enterprise Business Systems courses (EBC), where students will be provided with knowledge of business processes, systems, applications development and analysis practices are the foundations of the proposed framework for a reference curriculum in enterprise computing at the undergraduate level. One of the main objectives

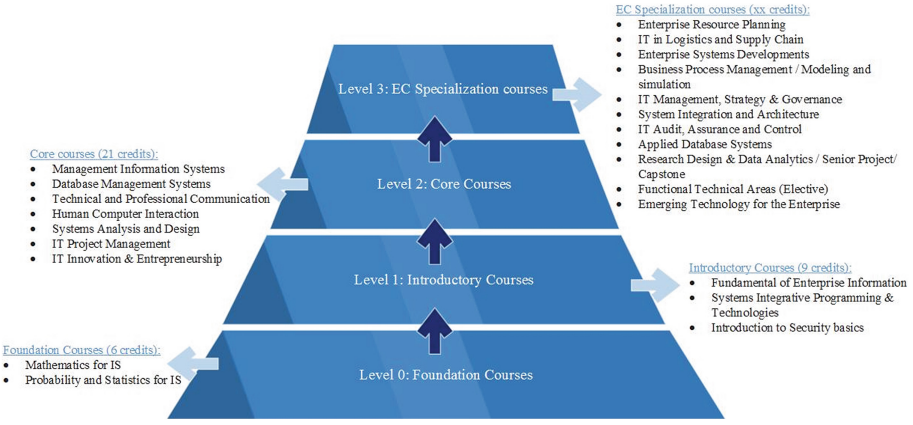


Fig. 2. Proposed framework for EC reference curriculum

of proposing a reference curriculum of enterprise computing is to try to bridge the gap between the expected enterprise computing competencies by the potential employers and the graduate enterprise computing program curricula.

The framework should support the development of new undergraduate programs in enterprise computing, and the enhancements to the existing enterprise computing undergraduate programs. The proposed framework has the following three dimensions:

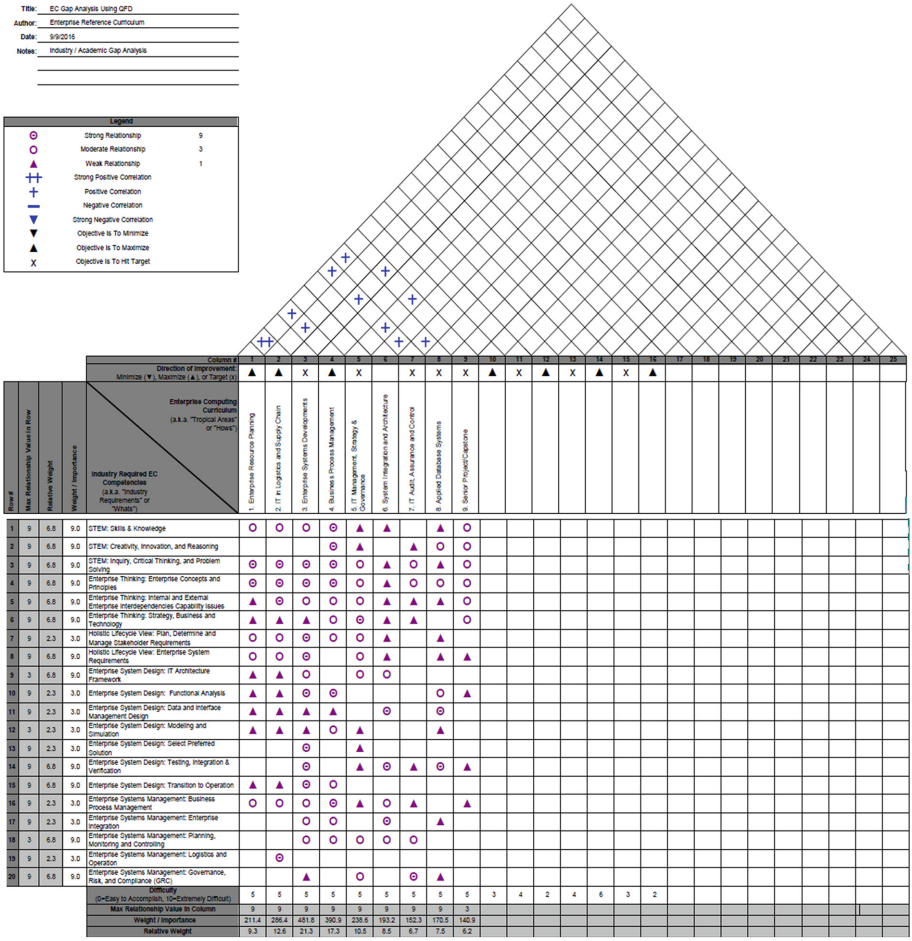
1. Topical areas of interest to academia and industry and needed by students
2. Four-Levels of Enterprise Computing related courses
3. Enterprise Computing competencies

Figure 2 shows the proposed enterprise computing reference curriculum framework in two dimensions. The proposed framework does not provide guidance on the number and titles of courses that an undergraduate program should have under each topical area. It assumes that the pedagogy of the courses is specific to each undergraduate program. Therefore, the pedagogy and undergraduate-level courses will evolve as the field of enterprise computing grows and matures.

8 Conclusion

The enterprise community realizes that there are many perspectives on the scope and content of an enterprise computing reference curriculum, and there is a need for relative convergence in this regard. The proposed reference curriculum uses a four-level approach, beginning with a foundation in statistics/mathematics and 9 introductory courses, and transitioning to 21 core courses supplemented with 11 advanced and special courses related to enterprise computing. The recommended framework consists of a baseline of several topical areas in enterprise computing and related subjects for universities to consider when developing an under graduate-level curriculum in enterprise computing.

Appendix A: Six-Sigma Quality Function Deployment (QFD)



Title: EC Gap Analysis Using QFD
Author: Enterprise Reference Curriculum
Date: 9/9/2016
Notes: Industry / Academic Gap Analysis

Legend

⊙	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
–	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
X	Objective Is To Hit Target	

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Industry Required EC Competencies (a.k.a. "Industry Requirements" or "Whats") / Enterprise Computing Curriculum (a.k.a. "Tropical Areas" or "Hows")	1. Enterprise Resource Planning	2. IT in Logistics and Supply Chain	3. Enterprise Systems Development	4. Business Process Management	5. IT Management, Strategy & Governance	6. System Integration and Architecture	7. IT Audit, Assurance and Control	8. Applied Database Systems	9. Senior Project/Capstone	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▲	▲	X	▲	X		X	X	X	▲	X	▲	X	▲	X	▲										
1	9	6.8	9.0	STEM: Skills & Knowledge	O	O	O	⊙	▲	▲		▲	O															
2	9	6.8	9.0	STEM: Creativity, Innovation, and Reasoning				⊙	▲		▲	O	O															
3	9	6.8	9.0	STEM: Inquiry, Critical Thinking, and Problem Solving	⊙	⊙	⊙	⊙	O	▲	O	▲	O															
4	9	6.8	9.0	Enterprise Thinking: Enterprise Concepts and Principles	⊙	⊙	⊙	⊙	O	▲	O	O	O															
5	9	6.8	9.0	Enterprise Thinking: Internal and External Enterprise Interdependencies Capability Issues	▲	⊙	O	O	O	▲	▲	▲	O															
6	9	6.8	9.0	Enterprise Thinking: Strategy, Business and Technology	▲	▲	▲	O	⊙	▲	▲		O															
7	9	2.3	3.0	Holistic Lifecycle View: Plan, Determine and Manage Stakeholder Requirements	O	O	⊙	O	O	▲		▲																
8	9	6.8	9.0	Holistic Lifecycle View: Enterprise System Requirements	O	O	⊙		O	▲		▲	▲															
9	3	6.8	9.0	Enterprise System Design: IT Architecture Framework	▲	▲	O		O	O																		
10	9	2.3	3.0	Enterprise System Design: Functional Analysis	▲	▲	⊙	⊙				O	▲															
11	9	2.3	3.0	Enterprise System Design: Data and Interface Management Design	▲	▲	▲	▲		⊙		⊙																
12	3	2.3	3.0	Enterprise System Design: Modeling and Simulation	▲	▲	▲	O	▲			▲																
13	9	2.3	3.0	Enterprise System Design: Select Preferred Solution			⊙		▲																			
14	9	6.8	9.0	Enterprise System Design: Testing, Integration & Verification			⊙		▲	⊙	▲	⊙	▲															
15	9	6.8	9.0	Enterprise System Design: Transition to Operation	▲	▲	⊙	O																				
16	9	2.3	3.0	Enterprise Systems Management: Business Process Management	O	O	O	⊙	▲	O	▲		▲															
17	9	2.3	3.0	Enterprise Systems Management: Enterprise Integration			O	O		⊙		▲																
18	3	6.8	9.0	Enterprise Systems Management: Planning, Monitoring and Controlling			O	O	O	O	O																	
19	9	2.3	3.0	Enterprise Systems Management: Logistics and Operation		⊙																						
20	9	6.8	9.0	Enterprise Systems Management: Governance, Risk, and Compliance (GRC)			▲		O		⊙	▲																
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	5	5	5	5	5	5	5	5	5	3	4	2	4	6	3	2									
				Max Relationship Value in Column	9	9	9	9	9	9	9	9	3																
				Weight / Importance	211.4	286.4	481.8	390.9	238.6	193.2	152.3	170.5	140.9																
				Relative Weight	9.3	12.6	21.3	17.3	10.5	8.5	6.7	7.5	6.2																

References

1. ABET: Accreditation Board for Engineering and Technology (ABET) (2016). http://www.abet.org
2. Association for Computing Machinery (ACM): Information technology – an academic discipline (2008). SIGITE, www.sigite.org
3. CBI: The voice of business, "learning to grow: what employers need from education and skills. Education and skills survey 2012". Survey sponsored by Pearson (2102)
4. European Commission: Competence development in SMEs. Observatory of European SMEs 2003, No. 1 (2003)

5. Hansen, A., Neupane, B., Lunt, B.M., Ofori, R.: Identifying and evaluating information technology bachelor's degree programs. In: SIGITE/RIIT 2012, Calgary, Alberta, Canada, 10–13 October 2012. http://sigite2012.sigite.org/wp-content/uploads/2012/08/session07-paper02.pdf. Accessed 22 Jan 2016
6. Lunt, B.M., Ekstrom, J.J., Gorka, S., Hislop, G., Kamali, R., Lawson, E., Leblanc, R., Miller, J., Reichgelt, H.: Curriculum guidelines for undergraduate degree programs in information technology. ACM (2008). http://www.acm.org/education/curricula/IT2008%20Curriculum.pdf. Accessed 19 Jan 2016
7. Jain, R.: A reference framework for systems engineering curriculum. In: Academic Council Presentation, INCOSE Symposium, 11 July 2006
8. Jain, R., Verma, D.: A report on curriculum content for a graduate program in systems engineering: a proposed framework. International Council on Systems Engineering (INCOSE)-PP-2007-001-01 (2007)
9. Jain, R., Squires, A., Verma, D., Chandrasekaran, A.: A reference curriculum for a graduate program in systems engineering. INCOSE Insight **10**(3), 9–11 (2007)
10. ManpowerGroup: 10th Annual Talent Shortage Survey (2015)
11. Marginson, S., Tytler, R., Freeman, B., Roberts, K.: STEM: country comparisons. Report for the Australian Council of Learned Academies (2013). https://dro.deakin.edu.au/eserv/DU:30059041/tytler-stemcountry-2013.pdf
12. Nightingale, D.: Principles of enterprise systems. In: Second International Symposium on Engineering Systems. MIT, Cambridge, Massachusetts, 15–17 June 2009
13. Roman, H.T.: STEM-its importance and promise for gifted students (2012). http://site.njtea.org/wp-content/uploads/2012/01/STEM-Article-for-IAGC-Journal.pdf
14. Shan, Y.P., Earle, R.H.: Enterprise Computing with Objects: From Client/Server Environments to the Internet. Addison-Wesley Longman, Reading (1998)
15. Topi, H., Valacich, J.S., Wright, R.T., Kaiser, K.M., Nunamaker, J.F., Sipior, J.C., de Vreede, G.J.: IS 2010 Curriculum guidelines for undergraduate degree programs in information systems Association for Computing Machinery (ACM) Association for Information Systems (AIS) (2010)
16. Laudon, K.C., Laudon, J.P.: Management Information Systems: Managing the Digital Firm. 14th edn. Pearson (2016). ISBN 13: 9780133898163